DECLARATION

I, Katsumi SUGIURA of 3-3-7-602, Hara, Inzai-shi, Chiba, Japan, do hereby certify that I am conversant with the English and Japanese languages and am a competent translator thereof. I further certify that to the best of my knowledge and belief the attached English translation is a true and correct translation made by me of U.S. Provisional Patent Application No. 60/135,843 filed on May 24, 1999.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Signed this 16th day of August, 1999

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[DOCUMENT NAME] SPECIFICATION

[TITLE OF THE INVENTION]

METHOD FOR COATING MASKING AGENT AND APPARATUS THEREFOR

[CLAIMS]

[Claim 1] A method for coating a masking agent, characterized in that a plurality of solid electrolytic capacitor substrates (2) are fixedly connected to a metallic guide (1) in a cantilever fashion, and a rotating disk (3) is brought into contact with the substrates (2) at a desired position at a predetermined pressing force while the metallic guide (1) is moved, thereby coating a masking material solution—which is fed from masking-material-solution supply means (4) to the coating surface of the rotating disk —to opposite surfaces and opposite side surfaces of the solid electrolytic capacitor substrate (2) at a desired position.

[Claim 2] The method for coating a masking agent as claimed in claim 1, wherein the relative position between the metallic guide and the rotating disk is inverted to thereby apply the masking material solution to opposite surfaces and opposite side surfaces of the substrate fixedly connected to the metallic guide.

[Claim 3] An apparatus for coating a masking agent, comprising: a metallic guide (1) to which a plurality of solid electrolytic capacitor substrates (2) are fixedly connected in a cantilever fashion; means for moving said metallic guide; a rotating disk (3) which comes into contact with the substrates (2) at a desired position at a

predetermined pressing force; means (4) for feeding to the coating surface of said rotating disk (3) a solution which contains the masking material; and a scraper (5) for cleaning the coating surface of said rotating disk (3); the apparatus being adapted to apply the masking agent to opposite surfaces and opposite side surfaces of the solid electrolytic capacitor substrate (2) at a desired position.

[Claim 4] The apparatus for coating a masking agent as claimed in claim 3, wherein the relative position between the metallic guide and the rotating disk is inverted to thereby apply the masking material solution to opposite surfaces and opposite side surfaces of the substrate fixedly connected to the metallic guide.

[Claim 5] The apparatus for coating a masking agent as claimed in claim 3, wherein two rotating disks are employed, and either one of the two rotating disks is dedicated to coating of the masking material solution to reversal surfaces of the substrates fixedly connected to the inverted metallic guide.

[Claim 6] The apparatus for coating a masking agent as claimed in claim 3, wherein two rotating disks are disposed on opposite sides with respect to the substrates fixedly connected to the metallic guide, thereby coating the masking material solution concurrently to opposite surfaces and opposite side surfaces of the substrate.

[Claim 7] The apparatus for coating a masking agent as claimed in any one of claims 3 to 6, wherein the substrate is

formed of a valve-acting metal, and the coating surface of the rotating disk comes into contact with the substrates at a pressing force which does not exceed the elastic limit of the substrate.

[Claim 8] The apparatus for coating a masking agent as claimed in any one of claims 3 to 7, wherein the rotating disk is formed of a steel material or ceramic material.

[Claim 9] The apparatus for coating a masking agent as claimed in any one of claims 3 to 8, wherein the scraper is the form of a blade which makes line contact with the coating surface of the rotating disk and which is formed of a resin or a steel softer than the material of the rotating disk.

[Claim 10] The apparatus for coating a masking agent as claimed in any one of claims 3 to 9, wherein a wiping material (6) comprising resin fiber soaked with an organic solvent and/or water is disposed downstream of the scraper with respect to the direction of rotation of the rotating disk.

[Claim 11] The apparatus for coating a masking agent as claimed in any one of claims 3 to 10, wherein means (4) for feeding the masking agent comprises a continuous quantity dispenser and a tubular member.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Technical Field to Which the Invention Belongs]

The present invention relates to a method and apparatus for coating a masking agent to a substrate of a solid

electrolytic capacitor. More specifically, the present invention relates to a method and apparatus for coating a masking agent capable of reliably insulating—when a solid electrolyte layer is formed on a valve-acting metal substrate having a dielectric film—a portion (anodic portion) of the metal substrate which is not coated with the solid electrolyte layer, from the solid electrolyte layer or from an electric conductor layer (cathodic portion) formed of an electrically conducting paste on the solid electrolyte layer.

[0002]

[Background Art]

A solid electrolytic capacitor, which uses a metal oxide such as manganese dioxide and a solid electrolyte such as an electrically conducting polymer, is configured in the following manner. An oxide dielectric film is formed on the surface of a previously etched or plated valve-acting metal, such as aluminum, tantalum, or titanium. A solid electrolyte layer is formed on the oxide dielectric film at a predetermined position. An anodic lead is connected to an anodic terminal (a portion of the surface of the metal which is not coated with the solid electrolyte) of the valve-acting metal. A cathodic lead is connected to an electric conductor layer including the solid electrolyte layer.

[0003]

Among the thus-configured solid electrolytic capacitors, a solid electrolytic capacitor using an electrically conducting polymer as a solid electrolyte is more useful in

terms of implementation of compact high-performance electronic devices than is that using an inorganic material as a solid electrolyte, since equivalent series resistance and leakage current can be rendered smaller.

In order to fabricate a high-performance solid electrolytic capacitor by use of an electrically conducting polymer, an anodic portion serving as an anodic terminal and a cathodic portion formed of an electric conductor layer including the electrically conducting polymer must be electrically insulated from each other in a reliable manner.

[0004]

Among others, the following methods for mutually insulating the anodic and cathodic portions of a solid electrolytic capacitor have been proposed: an epoxy or phenol resin, for example, is applied to an untreated portion through coating, printing, or potting, followed by hardening to thereby prevent electric conducting (JP-A-3-95910(the term "JP-A" as used herein means an "unexamined published Japanese patent application")); a poly(amic acid) film is formed at least partially on a portion of a valve-acting metal on which a solid electrolyte layer is not formed, through electrodeposition of a solution which contains poly(amic salt), followed by dehydration and hardening through application of heat to thereby form a polyimide film (JP-A-5-47611); a tape or a resin coat film portion of polypropylene, polyester, a silicone resin, or a fluorocarbon resin is formed in order to prevent crawling-up of a solid electrolyte

(JP-A-5-166681); and an insulating resin layer is formed on the surface of a boundary portion between a portion of a metal substrate which serves as an anodic terminal portion and a portion of the metal substrate where a capacitor portion is formed, and then the insulating resin layer is removed from a portion of the metal substrate other than the capacitor portion to thereby expose the valve-acting metal substrate (JP-A-9-36003).

[0005]

In the method which uses, for example, a phenol resin (JP-A-3-95910), the resin has a high elastic modulus; thus, strain induces a large stress. Therefore, upon being subjected to an external force, a capacitor element suffers significant damages. In the method in which the polyimide film is formed through electrodeposition (JP-A-5-47611), the polyimide film can be formed in pores, unlike the case of an ordinary coating process. However, the electrodeposition involves a high-temperature dehydration step, causing an increase in production cost. The method which uses the tape of an insulating resin (JP-A-5-166681) has a drawback in that reliably insulating end portions of the substrate is difficult. The method in which, after formation of an insulating resin layer, the insulating resin layer is removed from a portion of the metal substrate other than the capacitor portion to thereby expose the metal substrate (JP-A-9-36003) has a drawback in that the once-formed insulating resin layer must be removed.

[0006]

The applicants of the present invention studied a method for coating to a substrate, as a masking material, a heat-resistant resin, such as polyimide, which exhibits good insulating property and heat resistance, by means of a coating process.

According to a conventional process for applying polyimide to the substrate, poly(amic acid) serving as a precursor is dissolved in a solvent. The resultant solution is applied to the substrate, followed by heating at high temperature to thereby imidize the precursor. However, since this process involves heat treatment at a high temperature of 250°C to 350°C, a dielectric layer on the surface of an anodic foil is damaged by heat. In this connection, recently, there have been proposed polyimides capable of being hardened sufficiently through heat treatment at a temperature not higher than about 200°C. Through use of such a polyimide, the dielectric layer on the surface of the anodic foil becomes unlikely to suffer damages or destructions which would otherwise result from heat. These polyimides can be utilized in the form of a solution of any concentration (viscosity) suited for coating work.

[0007]

Other heat-resistant resins include polyphenylsulfone, polyethersulfone, and fluorocarbon resins (for example, tetrafluoroethylene and tetrafluoroethylene-perfluoroalkylvinylether copolymer). Such a heat-resistant

resin is dissolved or dispersed in a solvent, yielding a solution of any concentration (viscosity) suited for coating work.

[0008]

[Problems to be Solved by the Invention]

The inventors of the present invention conducted studies in an attempt to discover a method for reliably and efficiently applying a masking material to an etched valve-acting metal substrate and having a metal oxide layer formed on the surface, at a desired position (around an entire cross section) .

[0009]

The present inventors examined the following methods:

(1) A masking agent in the form of a fine string is hung down directly onto the surface of a substrate (formed aluminum foil) by means of, for example, a dispenser;

(2) A masking agent is applied to the surface of formed aluminum foil by means of, for example, a brush or a slender bar such as a bamboo skewer; and

(3) A masking agent is applied to the surface of formed aluminum foil through screen printing.

Methods (1) and (2) can apply the masking agent within a short period of time, but involve difficulty in maintaining stable work over a long period of time, because of partial solidification on, for example, a bamboo skewer. Further, since the surface of a typical porous formed aluminum foil repels the masking agent, linear application of the masking

agent is difficult, and thus the applied masking agent tends to become nonuniform. The screen printing method described in (3) can uniformly apply the masking agent to the foil surface, but involves difficulty in applying the masking agent to a predetermined thickness (10-30 μm/one surface) and in applying the masking agent reliably to side surfaces of the formed foil.

As described above, methods (1) to (3) involve difficulty in applying a masking agent uniformly and linearly around an entire cross section of a substrate.

[0010]

Next, in terms of efficient application of a masking agent to a number of substrates (formed aluminum foils), the present inventors have found promising a method in which a plurality of substrates are connected to a guide plate in a cantilever fashion, and a masking agent is applied to each of the substrates at a predetermined position and around an entire cross section thereof. Thus, the present inventors trial-manufactured, for study, an apparatus including: a device for moving a metallic guide to which the substrates are fixedly connected; a rotating disk having a circumferential surface which serves as a coating surface; a bath which contains a masking agent and allows the rotating disk to be partially immersed in the masking agent; and a scraper for scraping off residual material from the rotating disk. The circumferential surface, to which the masking agent adheres, is brought into contact with the lower surface

of the formed aluminum foil connected to the metallic guide plate, thereby applying the masking agent.

[0011]

However, the trial-manufactured apparatus involves the following problems. Since a solution which contains a masking material is contained in an open system (exposed to the air) during coating, the masking material is solidified in the vicinity of the scraper. Also, the viscosity of the masking agent contained in the bath varies, causing instability in coating. Thus, the solution which contains the masking material must be replaced at short intervals.

[0012]

The above-mentioned problems have been solved through employment of the following measures, thereby achieving the present invention.

(a) A plurality of formed foils (substrates) are fixedly connected, in a cantilever fashion, to a base (metallic guide) which moves linearly.

(b) A rotating disk is disposed such that the top of a smooth circumferential surface (coating surface) abuts, at a constant force, the back surface (lower surface) of the substrate, which is fixedly connected to the metallic guide.

(c) A solution which contains a masking material is stored in a closed container, and the masking agent is fed to the coating surface of the rotating disk through a closed system; specifically, through, for example, a resin tube or needle by use of a quantity coating-fluid feeder, such as a

continuous quantity dispenser of little pulsation.

(d) The rotating disk—whose circumferential surface serves as the coating surface and is uniformly coated with the solution which contains the masking material—is pressed against the formed foil, thereby applying the masking material to the lower surface and side surfaces of the formed foil substrate through adjustment of the traveling speed of the metallic guide plate and the rotational speed of the rotating disk.

(e) There is provided means for cleaning off the remaining masking material from a portion of the coating surface located downstream of the position where the rotating disk comes into contact with the formed foil substrate and upstream of the position where the rotating disk is coated with fresh coating solution.

[0013]

[Means to Solve the Problems]

The present invention provides:

[1] a method for coating a masking agent, characterized in that a plurality of solid electrolytic capacitor substrates are fixedly connected to a metallic guide in a cantilever fashion, and a rotating disk is brought into contact with the substrates at a desired position at a predetermined pressing force while the metallic guide is moved, thereby coating a masking material solution—which is fed to the coating surface of the rotating disk from means for feeding the masking material solution—to opposite

surfaces and opposite side surfaces of the solid electrolytic capacitor substrate at a desired position; and

[2] an apparatus for coating a masking agent, comprising: a metallic guide to which a plurality of solid electrolytic capacitor substrates are fixedly connected in a cantilever fashion; means for moving said metallic guide; a rotating disk which comes into contact with the substrates at a desired position at a predetermined pressing force and which has a smooth coating surface; means for feeding to the coating surface of said rotating disk a solution which contains the masking material; and a scraper and a wiping material adapted to clean the coating surface of said rotating disk; the apparatus being adapted to apply the masking agent to opposite surfaces and opposite side surfaces of the solid electrolytic capacitor substrate at a desired position by means of the coating surface of said rotating disk.

[0014]

[Description of Preferred Embodiments]

An apparatus for coating a masking agent to a solid electrolytic capacitor substrate (hereinafter referred to simply as "substrate") according to the present invention will next be described with reference to a plan view (Fig. 1(a)) and a side view (Fig. 1(b)) schematically showing an embodiment of the present invention.

The apparatus of Fig. 1 is adapted to carry out, during one rotation of a disk (3), one cycle consisting of the steps

of: feeding to the coating surface of the disk (3) a solution which contains a masking material; coating the masking agent to a substrate; and cleaning off the remaining masking agent from the coating surface of the disk (3).

[0015]

In Fig. 1, reference numeral 1 denotes a metallic guide to which a plurality of substrates (2a, 2b, 2c, ...) are fixedly connected in a cantilever fashion.

The substrates can be fixedly connected to the metallic guide (1) through electrical or mechanical bonding. Examples of a bonding method include soldering, bonding by use of an electrically conducting paste, ultrasonic welding, spot welding, and electron beam welding.

[0016]

The metallic guide (1) moves linearly around over the rotating disk (3) in the direction of the arrow. Customarily used means, such as a motor, belt, or cylinder, may be used as means (not shown) for moving the metallic guide (1). Through adjustment of the relationship between the traveling speed (V1) of the metallic guide and the rotational speed (V2) of the rotating disk, the side surfaces of the substrate (2) can be coated with the masking agent. Specifically, as shown in Fig. 2(a), when the traveling speed (V1) of the metallic guide is greater than the rotational speed (V2), the side surface of the substrate located forward with respect to the traveling direction can be coated with the masking agent. When the traveling speed (V1) of the metallic guide is

smaller than the rotational speed (V2), the side surface of the substrate located backward with respect to the traveling direction can be coated with the masking agent (Fig. 2(b)).

[0017]

The apparatus of the present invention also includes a mechanism for inverting the relative position between the metallic guide and the rotating disk, thereby coating the masking agent to opposite sides of substrates fixedly connected to the metallic guide.

An example of such a mechanism is an inverting mechanism for use with the metallic guide. Inversion can be carried out by use of a motor or cylinder, or by rendering a holder of the metallic guide rotatable about the longitudinal direction of the metallic guide and turning the holder by half-turn.

[0018]

In order to apply the masking agent to the reversal surfaces of the substrates fixedly connected to the inverted metallic guide, the relationship between the coating surface of the rotating disk and the coating position of the substrates must be adjusted. This adjustment can be performed by moving the metallic guide, moving the rotating disk, or moving both metallic guide and rotating disk by use of customarily used means.

[0019]

Alternatively, two rotating disks may be employed. Either one of the two rotating disks is dedicated to coating

of the masking agent to uncoated surfaces of the substrates fixedly connected to the inverted metallic guide.

Further, two rotating disks may be disposed on opposite sides with respect to the substrates fixedly connected to the metallic guide, thereby coating the masking agent concurrently to opposite surfaces and opposite side surfaces of the substrate.

[0020]

The rotating disk (3) has a smooth coating surface (3a), which comes into contact with the substrate at a desired position at a predetermined pressing force.

The rotating disk (3) is formed of a hard material resistance to a solution which contains the masking material; specifically, a metal (stainless steel, for example) or a ceramic material. The size of the rotating disk (3) may be such that the masking agent does not degenerate during one rotation of the rotating disk (3) (during one cycle of coating of the masking agent). The size of the rotating disk (3) is usually 2 mm to 500 mm in diameter, but is not particularly limited. The width of the coating surface of the rotating disk is selected so as to apply the masking agent by a desired width, and is preferably approximately 0.2 mm to 3.0 mm.

[0021]

There are disposed means (4) for feeding to the coating surface of the rotating disk (3) a solution which contains the masking agent upstream of the position of contact between

the rotating disk (3) and the substrate (2) (upstream with respect to the direction of rotation), and a scraper (5) and a wiping material (6) for cleaning the coating surface of the rotating disk downstream of the position of contact.

[0022]

The present embodiment employs, as the means (4) for feeding the solution which contains the masking material, a quantity coating-fluid feeder equipped with a closed continuous quantity dispenser of little pulsation. The quantity coating-fluid feeder feeds the solution which contains the masking material, to the coating surface of the rotating disk continuously at a predetermined flow rate through a resin tube resistant to the solution and by means of a discharge needle.

[0023]

In order to stably feed to the coating surface of the disk (3) the solution which contains the masking material, there is provided a fine regulating mechanism for stabilizing the distance between the tip of the needle and the disk surface. An example of such a mechanism is a micrometer head (screw mechanism) adapted to adjust a vertical position finely.

The coating surface of the rotating disk (3) fed with the solution which contains the masking material comes into contact with the substrate at a constant pressing force at the position of contact with the substrate. The pressing force is determined so as not to exceed the elastic limit of

the substrate and preferably such that the deflection of the rotating disk as measured at the smooth top (coating surface) falls within a range of from 0.03 mm to 0.3 mm. A specific pressing force depends on the type and thickness of the substrate, but may be set to, for example, about 0.002 g to about 0.02 g per substrate (3 mm (width) x 0.1 mm (thickness)).

[0024]

Next, the coating surface of the disk is cleaned. For example, the mechanical scraper (5) and the wiping material (6) are used as cleaning means.

The scraper (5) is the form of a blade which is formed of stainless steel or ceramic material as in the case of the disk or formed of a material (for example, resin or steel) softer than the material of the disk. The scraper (5) is disposed such that at least a tip comes into close contact with the coating surface of the disk so as to scrape off, from the coating surface of the disk, the masking agent which remains on the coating surface after application of the masking agent to the substrate is completed. The wiping material (6) is disposed downstream of the scraper (5) (downstream with respect to the direction of rotation) and includes resin fiber soaked with an organic solvent and/or water (for example, a solvent identical to that used in the masking material solution). The wiping material (6) is adapted to wipe off adhering substances from the coating surface of the disk, thereby preparing for the next coating

cycle.

[0025]

Since the apparatus of the present invention employs a nonpulsating drive system for feeding the solution which contains the masking material, from the closed container to the coating surface of the rotating disk, the solution can be fed stably.

[0026]

[Effects of the Invention]

As described in the foregoing, in the method and the apparatus according to the present invention for coating a masking agent to a solid electrolytic capacitor substrate, the masking material (for example, a polyimide resin) which is dissolved or dispersed uniformly in a solvent can be applied to the substrate continuously in the form of a straight line having a stable width each time a disk makes one rotation.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1]

Plan view (a) of an apparatus for coating a masking agent to a solid electrolytic capacitor substrate according to an embodiment of the present invention and side view (b) of the apparatus.

[Fig. 2]

Explanatory view showing application of the masking agent to side surfaces of the substrate.

[Description of Symbols]

1: metallic guide

2: solid electrolytic capacitor substrate

3: rotating disk

4: means for feeding masking material solution

5: scraper

6: wiping material

[DOCUMENT NAME] Abstract

[SUMMARY]

[PROBLEM TO BE SOLVED] To provide a method and an apparatus for efficiently coating a masking agent for insulating an anodic portion from a cathodic portion.

[MEANS TO SOLVE THE PROBLEM] A method and an apparatus for coating a masking agent, characterized in that a plurality of solid electrolytic capacitor substrates (2) are fixedly connected to a metallic guide (1) in a cantilever fashion, and a rotating disk (3) is brought into contact with the substrate (2) at a desired position at a predetermined pressing force while the metallic guide (1) is moved, thereby coating a masking material solution—which is fed from masking-material-solution supply means (4) to the coating surface of the rotating disk (3)—to opposite surfaces and opposite side surfaces of the solid electrolytic capacitor substrate (2) at a desired position.

[SELECTED DRAWING] Fig. 1